Computer-Aided Education of Cardiac Auscultation

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Cardiac auscultation is the difficult task of diagnosing heart disease based on sounds heard by an examiner. Auscultation is a useful and inexpensive diagnostic tool, but it is challenging to learn. Medical students are often given little formal training in this skill, and are instead expected to learn it in the course of their clinical training. Unfortunately, this often means that practicing auscultation is limited to occasions when teaching is focused on another area. Education in listening to the heart is even more difficult because of the dynamic nature of the hemodynamic system. Instructors often have trouble illustrating the many changes in the heart and great vessels as blood rushes through them. We are building an intelligent tutoring system which is designed to address these problems.

The *C*ardiac *A*uscultation *D*iagnosis *I*nstructor (CADI) has three components: a role-playing environment, a hypermedia textbook and a diagnosis builder. The role playing environment allows students to play a part within a scenario in which they must practice auscultation; the scenarios can be structured to target different skill levels from first-year students to residents. The hypermedia textbook provides information on basic auscultation as well as discussion of aspects unique to a scenario. The diagnosis builder asks students to reason based on what they've heard to arrive at a diagnosis, but using visual tools rather than natural language.

CADI's design is grounded in a pair of theories: *case-based reasoning* [1], a theory of cognition, and *goal-based scenarios* [2], a theory of educational design. Case-based reasoning purports that "reasoning is remembering" — people solve problems by recalling solutions to similar problems they have solved in the past. They do so by comparing the current problem to a library of problems (with solutions) using a similarity metric. After retrieving the most similar case, its solution is often adapted to fit the peculiarities of the new situation. Case-based reasoning seems to be a good explanation for the perceptual and diagnostic skills used in auscultation. Clinicians often compare the heart sounds of current patients to sound patterns they have heard in the past. In fact, they are often taught to do so. Thus, cadi's tutoring mechanism will be case-based.

The case-based approach is a departure from techniques currently used to teach auscultation. Many systems, such as those built by the Cardionics Incorporated, allow the instructor to manipulate the volume and quality of component sounds within a sound pattern. Thus, if a student has difficulty hearing the second heart sound, S_2, the teacher can boost its relative volume. CADI , on the other hand, will offer the student a chance to listen to patient with a similar set of sounds, but with a more pronounced S_2. Using this approach will allow students to broaden the range of sounds heard, while retaining the realism sacrificed by systems which create artificial sounds.

Goal-based scenario theory suggests a design for educational systems: rather than presenting material to students, who act as passive receivers, engage them in a task which requires the skills to be learned. In CADI, students are not presented with computerized lectures; instead, they are given a task: diagnose a patient. The students are given clues through auscultation, so to correctly diagnose the ailment they must learn to auscultate. By playing an active role in the environment, students will be more motivated to study the material presented, and hopefully retain more of it.

The hypermedia textbook provides information on demand. In CADI , students will use the textbook when they need specific knowledge. For example, a student who suspects they are hearing the sounds of ventricular septal defect in an infant might wish to review the pathophysiology of this defect. The difference in cadi's textbook is that students will consult *when they are ready to learn the knowledge presented there.* This is very different from offering students a CD-ROM packed with images and videos, but whose presentation lacks motivation.

The last component of the CADI system is the diagnosis builder. After the student is satisfied that she has heard the sound correctly, and has noted the sound pattern on the chart, she will need to arrive at a diagnosis and explain her reasoning. This component will allow students to construct explanations of the student's diagnosis, but without natural language. CADI will offer a simulated environment in which students can learn auscultation in an engaging manner, and receive feedback on their perceptual skills and diagnostic reasoning.

References

[1] Kristian J. Hammond. *Case-Based Planning: Viewing Planning as a Memory Task.* Academic Press, Boston, 1989.

[2] Roger C. Schank, Andrew Fano, Benjamin Bell and Menachem Jona. The Design of Goal-Based Scenarios. *Journal of the Learning Sciences*, 3(4):305-345, 1994.

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